Synopsis

"Development of Blended Nano-material Ceramics: It's Study for Applications in Gas Sensors and Waste Water Treatment"

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Abstract of proposed work plan/problem

1. Introduction:

There is always an everlasting lust of human to understand origin of our cosmos, which can be seen by detecting/examining various celestial objects, molecules and particles. However, tons of cosmic dust (in the form of liquid or volatile organic compound or gases molecules) reaches earth surface every year from the outer space [1] and pollute the environment as well as living organisms. In addition to this various hazardous chemicals/gases produced by so many chemicals, paint, pesticides, textile, etc. industries are also releases to enhance pollution in earth environment/water sources. Hence it is important to detect these chemicals/gases at laboratory scales and use them in outer space/waste water treatment purpose.

Celestial materials in outer space and on earth are simple as well as complex carbon containing organic/bio molecules. These carbon containing molecules can change their original identity due to the continuous ionization chain processes and can be detected using delicate spectroscopic/spectrometric techniques such as UV-Vis, FTIR, etc. techniques. Whereas, a simple technique is developed to detect them in their original state or ionized state by means of their adsorption on material/substrate, commonly termed as sensor material/substrate. The materials of the substrates should be such that atoms and molecules of gases/vapours should get adsorb reflecting change in electrical resistivity of the sensor substrate and also get removed at elevated temperature.

Industrial growth is completely related with the removal of a large number of a range of toxic pollutants that are harmful to the environment, hazardous to human health. Textile industry belongs to important sources of contamination via releasing many dyes into the water sources, which are difficult to decompose and may cause health problems like carcinogenicity, respiratory diseases, allergic reaction in eyes, skin irritation and irritation to mucous membrane and the upper respiratory tract etc [2]. That’s why to control the water pollution has becomes more important in the present scenario. Nowadays, enormous areas of research have been investigating large number of various types of waste separation technologies for treatment of waste water. Some examples are like: membrane filtration, ion exchange, ozonation, evaporation, crystallization, adsorption technologies, etc [3]. So this research topic would like to give assessment priority to adsorption technique; which is very recent, easy, and may be most applicable. This technique will use adsorbents like some natural, waste, minerals, novel, nano, biological, etc material. And other than these adsorbents, nano material ceramics, cellulose, polymers, can be used as an absorbent as a base material in the form of powder or tablets, because of its high porosity, high surface area, high surface to volume ratio and other adsorption property. We can also improve adsorption properties of such nano ceramics by mixing other nano materials and also this technique will give importance to modified activated carbon materials as for better adsorption.

2. Review of Literature and development in the subject (Previous Work done in the relevant area):

In interstellar space, astronomers detects gaseous molecules such as (i) Carbon mono oxide, (ii) Carbon dioxide, (iii) simple alcohols like Methanol, Propanol, etc. (iii) Complex alcohols like Ethylene Glycol, Glycerol etc, (iv) Ten different Aldehydes like formaldehyde, glycolaldehyde, acetaldehyde, propanal, propenal, lactaldehyde, glyceraldehyde, glyoxal, methylglyoxal, and butyraldehyde etc, (v) Hydrocarbons especially Poly aromatic hydrocarbons like pyrene, anthracene, naphthalene, etc (vi) Methyl Format, (vii) Acetic Acids, (viii) Hydrogen Cyanide, Hydrogen sulphide, Acetylene, and nitrogen bearing organic molecules like ammonia, amino acids etc [4-16]. All above mentioned molecules are playing very essential role in the life of the living organisms. For example sugar related molecule i.e. Glycolaldehyde is essential component to form RNA, having similar function as DNA and thus suggesting important component in cosmic evolution process. These molecules help us to know and understand origin of our cosmos, and they also essential for the life of the living organisms and as a building block for the earth. This discovery may be an important key to understand the formation of life on the earth. Researchers detected or examined these molecules by Spectroscopic/Spectrometric technique. Nowadays, adsorption technique becomes very useful as well as essential for sensing or detecting purpose, because it is easy for experiment.

This adsorption technique is based on materials which having adsorption characteristics. Recently, Nano and Novel materials are considering as a unique absorbing material and hence they used for sensing as well as for waste water treatment.

Waste water, released from organic, inorganic, dye, paint, domestic sources, etc. are now becomes very important issues. Here, one of the best applications of nano ceramics, cellulose and polymers is in the treatment of waste water. These different materials will have different adsorption capacities for elements like cadmium, zinc, arsenic, antimony, fluoride, and other than elements like dyes: Rhodamine dye, Brilliant blue dye, Indigo carmine dye etc, released from different textile industries [17-19].

3. Objectives of Research/ Proposed Hypothesis:

A) Objectives related to sensing application:

The ideal substrate for gas sensor should have properties such as large surface to volume ratio, high porosity, affinity to adsorbates and easy to desorbs the absorbed gas/vapours molecules.

- To synthesize the materials for sensing purpose
- To modify sensing material via blending with nano materials
- Characterization of the synthesize nano material's and blended nano material's powder, by XRD, AFM, TGA/DTA, FTIR, Raman analysis, Auger electron analysis and X-Ray photo electron spectroscopy techniques.
- Design and fabricate a suitable sensor setup

- The fabrication of thick films as a sensor substrate for sensing the molecule
- Sensing mechanism study between sensor substrate and adsorbed molecules

B) Objectives related to Waste water treatment:

- To synthesize the materials for waste water treatment purpose
- Characterization of the synthesize nano material's and blended nano material's powder, by techniques like XRD, AFM, TGA/DTA, FTIR, Raman, Auger electron and X-Ray photo electron spectroscopy techniques
- Synthesize/take selective waste water, especially which is polluted by dye
- Use synthesize material for removal of dye by using adsorption experiment
- Adsorption experiment which is based on kinetic models for investigation of effect of different parameter
- Examined concentration of dye remained in water by using UV-Visible spectrometer
- Adsorption study for determination of % removal from dye solution ye using some isotherms

4. Methodology to be adopted:

The study will comprise of the fabrication of Hydroxyapatite nano ceramics as a basic material, have been successfully applied as promising candidate for fabricating gas and chemical sensors devices, due to their porous and open cage nano size structure, large surface area, and ionic conductivity [20-25]. Its highly porous nature works as an accumulation sites as well as conduction path for adsorbed gas molecules. Also the P-OH group determine the reactivity with gas molecules since they act as an adsorption sites for the gas to be sensed. Calcium and phosphate are the two elements that composed Calcium Hydroxyapatite (HAp), with a third element is hydroxide [20, 23, 24, 25]. This consists of hydrogen atom joined with oxygen in a chemical bonding that involves sharing electrons with each other. HAp behaves like an effective sensor material with characteristics like high sensitivity, fast response, good selectivity, and stability for the detection for sensing carbon containing simple/complex molecules as well as such molecules which contains Amino group, in their meagre quantity. The sensitivity of such nano porous matrix can further be considerably enhanced by dispersing a low concentration of additives on its surface or in its volume.

The sensor substrates are modified by blending with nano materials such as Graphene, Carbon Nano Tubes and Reduced Graphene Oxides as well as nano metal oxide of Ti, Zn, Co, etc [26-30]. The sensor substrate can also be modified by addition of carbon containing materials like Cellulose nano fibres (CNF) and Tempo-CNF in hydroxyapatite nano ceramics as a one can be used as a starting precursor during preparation and also can be mixed mechanically after preparation.
For fabrication of sensor devices firstly we will synthesized the materials by using different methods. For example, the Nano-ceramics Hydroxyapatite material for sensor devices shall be

prepared in its nano form by using Wet chemical precipitation or hydrothermal or solid state method etc. This HAp material and the material which we want to blend with HAp, will be converted in the powder form by crushing material mechanically. This powder then we will use for characterization by different characterization techniques such as XRD (X-Ray diffraction), SEM (Scanning electron microscopy), AFM (Atomic force microscopy), TGA/DTA (Thermo gravimetric analysis/Differential thermal analysis), FTIR (Fourier transform infrared spectroscopy), etc, for determining grain size, surface to volume ratio, morphology thermal stability i.e. for determining the change of phase or structure at elevated temperature, functional groups, present in the material. If any, Raman analysis for nano grain size, Auger electron analysis for knowing adsorbed atomic species at atomic level and X-Ray photo electron spectroscopy for determining the molecules on the sensor substrate with their absorption state. The other characterization will be used if required for further analysis.

A) Development of substrate for sensing purpose:

The synthesized powder will be used to form thick films by using screen printing techniques with the help of some binding materials like glass frit, BCA, and ethyl cellulose, which will be subsequently be heated at elevated temperature for sintering purpose. These thick films are now called as sensor films which will be subjected to electrical study by two probes or four probes methods. In this set up, change in electrical resistance will be compared for the films when exposed in air as well as when exposed in vapours (gas molecules) under test, while keeping the sensor substrate at various temperatures. This study will give the actual temperature at which the gas molecules will get detected by the sensor effectively. Later on the figure of merit of sensor device, viz., response and recovery time for these films will be determined by keeping them at their operating temperature. This time factor assesses these films for their commercial exploitations as a sensor for space applications. Further these films will also be assessed for their ultimate maximum uptake capacity.

B) Development of substrate for Waste water treatment purpose:

The synthesized powder will be used directly or in the form of tablets for the waste water treatment. The adsorption experiment will be carried out for determination of adsorption capability of synthesized material. Experiment will be conducted by using aqueous solution of dye with different concentration in accordance with the maximum allowable limit selected by world health organization for determined volume. During this experiment we will use kinetic models for investigation of effect of different parameters like time duration, dose of adsorbents, PH of solution etc. Then after performing experiment, we will take UV-Vis spectroscopy for determining the concentration remained in the aqueous solution. The percentage of dye removal and amount of dye adsorbed per weight of adsorbent will be calculated by using different types of isotherms like Langmuir Isotherm and Frandlich Isotherm.

5. Importance of study/ Society Application:

A) International Status:

In sensing area of research

Luo Lan.l et.al, has prepared tube-like pure Hydroxyapatite and Au-Hydroxyapatite (Au nano particles mixed with Hydroxyapatite by using hydrothermal treatment) powders for sensing ammonia gas at room temperature [31]. Li Huixia et.al, has compared the physical properties of the rod-like and tubular Hydroxyapatite, for determining which hydroxyapatite provide efficient adsorption characteristics for the ammonia gases depend on reaction between the adsorbed atmospheric oxygen i.e.H_2O and the intermediate compound of the ammonia molecule after donating proton [32]. E. Peon et.al, has confirmed the porous structure of hydroxyapatite by developing hydroxyapatite pore blocks by pressing and heating to hydroxyapatite powder with 47% porosity and having 50-120 µm pore size [33]. Dagmara Malina et.al, has investigated the effect of sintering process at different temperature on microstructure and morphological properties of sintered hydroxyapatite which is prepared by the wet chemical precipitation method [34]. Qing Zhang et.al, reported that synthesis of Hydroxyapatite/graphene hybrid materials with enhanced sensing performance towards ammonia gas. In this work, he developed the needle-like and micro-spherical agglomerates of nano crystalline Hydroxyapatite were successfully assembled on the surface of graphene sheets [35]. Qi-Long Yan et.al, reviewed that extensive investigations were and are currently being conducted regarding the design, synthesis, characterization and application of various carbon nano materials or functionalized carbon nano materials (CNMs) in energetic material (EMs). He worked on widely used CNMs include, graphene, graphene oxide, RGO, CNTs, activated carbon fibers and EG as well as functionalized graphene and C_{60}-fullerene [36].

In waste water treatment area of research

Gunatilake S.K. from Srilanka reported the methods such as, physic-chemical removal process, adsorption on new adsorbents, ion exchange, membrane filtration, electro dialysis, reverse osmosis, ultra filtration and photo catalysis, and another one new method is bio adsorption, it is a new biological method and used various low cost biological adsorbents (agricultural waste, forest waste, industrial waste, algae etc) are used for maximum removal of heavy metals from industrial waste water [37]. Shu-Dong Jiang et.al, developed a new synthetic routes to 3D Hydroxyapatite based hollow microspheres through a water soluble biopolymers (poly aspartic acid) assisted assembly from hydroxyapatite nano rods in application of water treatment [38]. Satriawan Dini Hariyanto et.al, presented the fabrication of Hydroxyapatite discs as a filtration medium in waste water treatment system. HAp powder made by cortical bovine bone. This powder then pressed in disc form and then used as a filtration media.SEM/EDX results shows the disk surface has interconnected micro pores and Ca/P ratio value on sinterd HAp disc at 1000^0C and 1400^0C are 2.20 and 1.85 respectively [39]. S. Hamzah et.al, studied the synthesis and characterization of Hydroxyapatite/ chitosan bio composite for Remazol Blue dyes removal. He extract Hydroxyapatite from egg shell mixed with chitosan to improve its mechanical strength and adsorption capacity. He observed that developed adsorbent achieved the highest adsorption capacity for about 95% dyes removal [40]. Mohammad Reza Foroughi et.al, reported the synthesis of hydroxyapatite powder by sol-gel method for industrial waste water treatment process in the elimination of heavy metals from

industrial effluent solution, with the relative removal of cadmium and also the complete removal of lead [41]. M. Ozawa et.al, determined the capability of fish bone Hydroxyapatite to removal of Cr in water [42].

B) National Status:

In sensing area of research

M.P Mahabole et.al, has reported the synthesis, characteristics and gas sensing properties of hydroxyapatite ceramics [43]. R.U. Mene et.al, has prepared hydroxyapatite nano ceramic thick films as an efficient CO_2 Gas Sensor [44]. R. U. Mene et.al, has developed Fe doped hydroxyapatite thick films modified via swift heavy ion irradiation for CO and CO_2 gas sensing application [45]. R.S. Khairnar et.al, has synthesized the Carbon nanotube doped nano-hydroxyapatite sensor matrix for gas sensing application [46]. S.R. Anjum et.al, has worked on integrated sensing of alcohols like methanol and ethanol by developing pure hydroxyapatite and CNT blended hydroxyapatite sensor substrate [47, 48, and 49]. J. Kathirvelan et.al, has developed the electro-chemical gas sensor for multi-gas detection application [50].

In waste water treatment area of research

R.M. Bhardwaj et.al, has reported the status of waste water generation and treatment in India [51]. Prachi et.al, reviewed role of nanotechnology in Waste Water Treatment [52]. Dr. M.Husain et.al, investigate the use of maize husk fly ash as an adsorbent for removal of fluoride [53]. Dr. Pankaj Singh et.al, reported about the domestic waste water treatment by fly and wood ash along with additives materials [54].

C) Significance of study:

This study signifies the development of novel materials for sensing of harmful and hazardous gases in earth environment as well as utilization of this novel material for waste water treatment via treating domestically or industrially polluted water to make it useable for domestic purpose (like gardening, washing, etc.) and further treatment can also make it drinkable too. This research work will have positive impact on the human society via providing better living environmental conditions.

6. Proposed work plan/ formulation and structure of study

Year wise plan of work and targets to be achieved											
Sr. No	***Work plan***	***First Year***		***Second Year***		***Third Year***		***Fourth Year***		***Fifth Year***	
		1 to 6	***6 to 12***	***1 to 6***	***6 to 12***	***1 to 6***	***6 to 12***	***1 to 6***	***6 to 12***	***1 to 6***	***6 to 12***
1	Course work	.....									
2	Literature study	.....	.....	.....							
3	Chemicals collection	.....	.....	.....	.....						
4	Materials preparation	.....	.....	.....	.....	.....	.....				
5	Characterization of material		.....	.....	.....	.....	.....				
6	Modification of material			.....	.....	.....	.....	.....			
7	Design and fabrication of Sensing setup		.....	.....	.....	.....	.....				
8	Preparation of thick films from prepared material		.....	.....	.....	.....	.....	.....	.....		
9	Investigation of gas sensing behaviour of material for space appl.			.....	.....	.....	.....	.....	.....		
10	Adsorption study of prepared material in waste water treatment		.....	.....	.....	.....	.....	.....	.....		
11	Data collection & result analysis		.....	.....	.....	.....	.....	.....	.....		
12	Paper writing for journals & conferences, Presentation of papers presentation in national and international conferences					.....	.....	.....	.....	.....	.....
13	Report Writing		.....		.....		.....		.....		.....

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